A Case Study Approach to STEM Supervision: A Collaborative Model for Teaching and Principal Preparation

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ABSTRACT

School principals are responsible for supervising STEM teachers, yet many principals did not teach in the STEM fields and have limited training in STEM content, process and practice. This presents a challenge for principals when they observe STEM classrooms and provide feedback to teachers. In this paper the authors describe a study about principals' views of STEM classrooms and the observational feedback principals provide to those teachers. The results of the study suggest principals need a deeper understanding of reform minded STEM process and practice, and alternative approaches to providing teachers with observational feedback. Building on the results of the study, the authors present a collaborative model (Innovating Teaching and Learning Leadership (iTALL)) for preparing pre-service principals and pre-service STEM teachers and describes training in the STEM process and practice. Observational exercises are discussed and changes in observational protocols when conducting classroom walk-throughs are described.

Key Words: *Instructional Leadership; Principal Education; Supervision; STEM Process and Practice*

Introduction

Principals are responsible for promoting school improvement (DuFour & Fullan, 2013; Glickman et al, 2013; Matthews & Crow, 2010; Duke, Carr, & Sterrett, 2013) and have a fundamental role as instructional leaders in schools (Hallinger & Murphy, 1987; Leithwood, 1992; Matthews & Crow, 2010; Waters, Marzano, & McNulty, 2003; Sterrett, 2011). Furthermore, student achievement is affected, at least indirectly, by the principal's leadership (Bambrick-Santoyo, 2012; Cotton, 2003). Principals have the complex task of working with teachers at numerous grade levels and subject areas, yet there is limited research about how secondary-level administrators address content-specific instruction (Lochmiller, 2016). One way in which principals work with teachers is through supervision of classroom instruction. Given the recent significance placed on science, technology, engineering, and mathematics (STEM) instruction promoting student literacy and success, reports have cited an urgent need for improving both the quality and the size of the STEM teacher workforce in the United States (National Research Council, 2011; National Science Board, 2007). The role of principal as instructional leader of STEM instruction is critical. Unfortunately, many principals have not had formal training, teaching experience, or professional development in the STEM areas (Sterrett, Rhodes,

Kubasko & Fischetti, 2018). We provide more details about supervision and the STEM process and practice in the following sections.

Supervision and Walk-throughs

Sullivan and Glanz (2013) describe supervision as "the process of engaging teachers in instructional dialogue for the purpose of improving teaching and increasing student achievement." (p. 4). Principals need to be more collaborative and assist teachers with reflection on instructional practice (Sullivan & Glanz, 2013). One instructional leadership strategy to address the above mentioned need is for principals to conduct walk-throughs with teachers. Walk-throughs are short, non-evaluative, and focused observations to provide feedback to teachers (Kachur, Stout, & Edwards, 2013; Zepeda, 2009). However, not all walk-throughs affect student learning (Moss & Brookhart, 2015). Traditional walk-throughs are evaluative and the principal may attempt to "fix" defective teaching practices (Sullivan & Glanz, 2013). The traditional view on walk-throughs is less effective. For student achievement to rise, principals need to frame walkthroughs as a learning process for themselves, provide effective feedback, and promote professional growth (Grissom, Loeb, & Masters, 2013). Principals may, or may not, have received some training on how to conduct walk-throughs. Given that they are coming from a variety of teaching backgrounds, they may notice different aspects

of STEM classroom instruction or have varied interpretations (Sterrett, Rhodes, Kubasko & Fischetti, 2018). As a result, it might be reasonable to infer that the messages they convey to teachers about STEM processes and practices are of an inconsistent nature.

STEM Content and STEM Process and Practices

Integrated STEM reforms in education serve to reduce the traditional barriers that separate the four disciplines while promoting the intersection of content-area instruction leading to interdisciplinary solutions to existing real-world problems (Breiner, Johnson, Harkness, & Koehler, 2012; NGSS Lead States, 2013). Furthermore, the shift in STEM education "is not about the subject but about the learning process of inquiry, imagination, questioning, problem solving, creativity, invention, and collaboration" (Myers & Berkowicz, 2015, p. 8). It is unrealistic to expect principals to be experts in all content areas. However, without a deep understanding of STEM teaching and learning, school-level leaders and principals may find it difficult to evaluate and support teachers' efforts to meet the needs of STEM students (Glickman, Gordon, & Ross-Gordon, 2010).

While we can't realistically expect all principals to have an in-depth knowledge of STEM content, it is important for them to understand some of the critical components of the STEM processes and practices. According to survey data collected by Breiner, Harkness, Johnson and Koehler (2012), it was concluded that even STEM professionals are confused as to what STEM means. This presents some challenges for effective observational feedback leading to the teacher growth we expect to see in STEM-infused classrooms. Teachers receive general pedagogical guidance and support from their administrators, thus, we assert that effective professional development for principals helps them understand some common STEM instructional processes and practices that will lead to improved feedback for teachers.

Research Questions

Given the lack of or limited STEM instruction training for principals, it is vital to consider how they view STEM instruction and investigate potential ways that preparation programs can provide STEM training within the university program. In this paper we describe a study about principals' views of STEM classrooms as well as propose a collaborative model for change. We answer the following two research questions:

1. What are principals' views of STEM classrooms?
2. What feedback do principals provide to STEM teachers after observing their classroom?

Based on the results, we share a collaborative model designed to serve both our principal- and teacher-preparation programs.

Principals' Views of STEM Classrooms and Feedback

Methodology

In this study we investigated how four middle grades principals across one county viewed STEM classrooms. The study was funded by a university award, the Charles L. Cahill Grant for Faculty Scholarship, at the University of North Carolina Wilmington. We employed a semi-structured interview and asked multiple questions about STEM classrooms and the feedback principals would provide to the teachers. For consistency purposes, one researcher conducted all the interviews, and recorded and transcribed the conversations for accuracy. Two researchers separately coded participant responses and assigned meaning. Both researchers collaborated to qualify any emergent themes generated across the codes. Emergent themes were placed in context and highlighted from each of the respondents. All interview responses, codes and emergent themes were collected in a Microsoft Excel spreadsheet. Researchers discussed and debated the emergent themes for accurate identification, importance and application. Patterns within and across respondents were recorded.

Results

As noted in Table 1, the four principals had different teaching backgrounds and experiences. Principal A had worked as a school counselor for three years prior to becoming a school administrator. The other three principals had taught in public schools for at least 12 years; Principal B was a middle school mathematics teacher, Principal C was a high school science teacher, and Principal D was a middle school teacher. All three participants taught core subject areas (math, science, social studies, and language arts), and two of them taught a field within STEM.

Table 1 *Middle School Principals' Teaching and Leadership Experience*

Name (anonymized)	Years of teaching experience	Subject area teaching experience	Years total as school administrator (including assistant principal	Years as principal
Principal A	3	Middle School Counselor	11	9
Principal B	12	Middle Grades Math	10	7
Principal C	15	High School Science	10	4
Principal D	12	Middle Grades Math, Science, Language Arts, and Social Studies	11	7

In terms of teaching styles, all four principals considered themselves student-centered, using terms such as "workshop style," "hands-on," "inquiry-based," and "engaging." Only one participant described whole-group instruction as being meaningful; the other three tended to focus on phrases such as "PBL," "hands-on and relevant" and "workshop" when discussing what sort of instruction, they hoped to see in the classroom.

Principals' views. All four principals were asked what they hope to see when observing a STEM classroom. While the principals' responses varied when answering the question, there were two common themes that emerged from the interview data. The first theme to emerge was that all principals were expecting to observe engaging hands-on activities in the teacher's classroom reflecting STEM teaching processes familiar to them. Principal A was clear in her assertion that she hoped to see "engagement, higher-order thinking skills, and problem-solving, inquisitive learning, inquiry-based." She also recognized that STEM-infused classrooms can sometime seem chaotic to the outside observer, but principals need to look deeply at the variety of activities happening, sometimes simultaneously. When discussing the need for teachers to be engaging, Principal B said, "my desire for that is to be as hands-on as we can make it." He acknowledged that there may be external influences to consider, "let me say I definitely think the push is to make their classes more engaging, more hands-on," Principal C stated that "I want to see them actively learning, they shouldn't just be sitting and getting. Everybody should be

experimenting or working on their engine or doing the flight simulation…" Lastly, Principal D referenced an interest to observe technology integration in the class. She stated, "During that time we try to bring in some STEM activities that the students can use that are necessary with a laptop and things like that, but just with the idea of being creative and building things with your own hands." Principal D consistently referenced technology integration as a function of STEM.

The second and extremely interesting theme is the perceived obstacles and barriers faced by both middle school STEM-infused teachers and the principals that observe their classrooms. STEM content understanding seems to be one of the consistent challenges for the principals. For instance, Principal A states:

> [In] the STEM class, if you didn't know what you were going in and looking for, it might look chaotic, because at any one time there's 10 modules that the students are working on so these two kids might be building a rocket, and these two might have a saw out and actually doing construction, and these kids over here are doing landscape design or architecture, so you have to understand what you are going in and seeing.

She asserts that principal observers need to take into consideration a preconceived STEM context necessary for effective observations. Principal C further supports that assertion when she states that "I expect there to

be chatter and motion, when I go in there, very different than when I walk into a regular math classroom." Principal B acknowledges that time is a barrier to integration and states "I think that teachers, I don't know that we set teachers up to be successful in a normal 60-minute class period to be great STEM teachers." He continues to say "the whole understanding of content doesn't just come overnight. Like the depth of understanding, so there's work that has to be done with new teachers where they may make their shifts more easily, their content knowledge is less." Content knowledge in science and mathematics, or lack thereof, is another challenge recognized by Principal B, especially for new middle school teachers. Lastly, Principal D alludes to there being different STEM expectations for different teachers as they navigate the idea of 'flex grouping'. She continues to say "within that flex grouping we have three levels, one of them is an enrichment level" where the expectation is that technology is infused throughout the classroom. This is not the case in the general or applied levels where there are "STEM activities the students can use that are necessarily with a laptop and things like that, but just with the idea of being creative and building things with your own hands. But not necessarily the technical piece." It seems that this principal is prepared to observe classroom teachers with different STEM expectations based upon student grouping. It is important to note that these responses all materialized in the context of the original question.

Principals' feedback to teachers. Principals were asked to reflect on their feedback to teachers after an observation. The focus of the interview feedback, as to be somewhat expected, primarily emphasizes student engagement in the classroom. But, a distinct and common theme to emerge is that the middle school principals interviewed make no mention of providing feedback about STEM content or process. Principal A has very clear questions as to what she wants addressed during her teacher observations. She commented in the interview, "I think [the feedback] would be exactly the same. Are students actively engaged? [The students typically work in pairs]… so is one student sitting and letting the other student do all the work? Is there shared ownership of the projects that they're working on? Are they actively engaged? Are they adhering to the expectation[s] of the classroom?" She

makes an assumption that a STEM classroom only requires there to be group work around projects that are collaborative in nature. Principal B was similar in that the feedback is primarily about student engagement and interactions. He stated, "Well, I would provide specific feedback for the type of lesson it is. I don't know that I want to go into a class and say this is a science-math class so I'm going to give this type of feedback. The content to me doesn't dictate the feedback. Of course, content knowledge is something that is important, but what are the students doing when you're observing?" It is interesting that he addresses teacher content knowledge and practice as being important but not at all the focus of the feedback. Again, Principal C's feedback reflected a focus on the kids and their engagement with the lesson. She said, "I like to go back to the teacher and we sit down and talk about where the kids really engaged? Could they talk to me about what they were doing? Or were they just kind of going through the motions." Student engagement is paramount to feedback about STEM learning. Lastly, Principal D's feedback to teachers is about creativity and out of the box thinking. She states "When it comes to STEM…I don't necessarily feel like we need to be always looking at them with the assignment of a grade because really the piece of this is that they can be as creative and far-reaching in their thinking as they can be." It is clear from the interviews that student engagement is a primary focus for these middle school principals. What is missing from the principal feedback provided to teachers are conversations about STEM content knowledge or applicable teaching processes and practices.

When providing feedback to teachers, principals were asked to identify the challenges they face when observing STEM classrooms. Three principals expressed challenges of familiarity and understanding of STEM content, while two of the principals articulated issues of STEM process. Principal A was honest about her lack of content knowledge in the discipline and its impact on providing teachers feedback. She stated, "So, I don't always have the content knowledge, so that is hard for me." She elaborated later in the response saying, "That's the biggest struggle; it's impossible to be the expert in all disciplines at all grade levels, and so I think you have to just rely on what you know works and what learning should look like, to know that it's going to turn

out okay." Principal B didn't feel limited by the content when providing feedback to his STEM teachers. He said, "There are certain behaviors that are appropriate across content, certain levels of engagement, certain levels of rigor that you look for. And so I do think there's a lot of crossover." This could be due to his background in middle school mathematics. He went on to say that his challenges are more a product of process, saying, "My challenges specifically to STEM teachers, though, is helping them see more best practices, so if I wanted to say one thing that's a challenge for developing STEM teachers at…middle school…it is letting them see better examples of excellence." Principal C quickly highlighted the learning process as being her biggest challenge when answering the question. She stated, "I think the challenge is that they're all doing something different and so it's not your typical instruction." With a background in science education, Principal C finds the style of active classroom led by her STEM teachers difficult to measure. She goes on to say that there are challenges with assessing STEM content and understanding. "I've got the math standards and I've got the science standards and I understand it, but [the issue is] for me as far as making sure they understand it." Principal D also has some concerns about challenges in providing feedback about the STEM content. She is quick to question her ability in "understanding the technology myself…Now the math is not an issue, although it's been a long time."

Discussion related to STEM process and practice. Observing and understanding STEM process and practice in a classroom does maintain some similar characteristics to good pedagogical process and practice. Myers and Berkowicz (2015) argue that we should expect to see an environment that empowers students to be active, engaged, innovative and creative. The interview data suggests that all four principals have at the very least a cursory understanding of STEM process and practice consistent with reform minded pedagogical strategies. For instance, Principals A and D, while both limited in their understanding of STEM content, recognize that STEM-infused classrooms require a high degree of creativity and active learning for students to be successful. Principal A even employs terms such as "inquiry", "problem-based learning" and "collaboration". Consistent with reform-minded strategies, Principal D argues that technology integration

is critical for student learning in STEM (Bybee, 2013). One would expect that based upon Principals B and C's STEM backgrounds, an understanding of STEM process and practice in the middle school classroom shouldn't be foreign. And the data suggests that it wasn't. The idea that STEM requires active learning leads Principal B to assert that time is a consideration for teachers and students. STEM teachers have argued that time is always a limiting factor in their success with engaging students in activities and exercises consistent with addressing pedagogical strategies such as problem-based learning. Principal C expects to see students engaged in "experiments" and "doing" in class. Active learning is consistent with effective STEM-infused classrooms.

Conversely, the interview data informs us about the principal's depth of understanding of STEM process and practice. In many ways, all four principals exhibited limited views, and this reality creates some questions to consider. Principal A was extremely honest in her challenges providing feedback to STEM-infused teachers. She relied on the familiar and traditional pedagogical strategies to guide reflective feedback to her teachers. Student engagement, while symptomatic to good teaching, isn't necessarily a STEM process or practice. If principals observe student engagement in a STEM-infused class, should the observing principal be satisfied with the teaching? If so, are there any recommendations being offered to the practicing teacher for changes or adjustments in process or practice specific to STEM? Additionally, principals make no mention of the interdisciplinary nature or crosscutting concepts foundational to STEM education reforms (Bybee, 2013). Principal B consistently talks about the similarities and differences between "math" and "science" content classes. Content knowledge is important. But is there any observational expectation that STEM teachers work across their disciplines in an integrated fashion? Principal C contrasts her expectations for observing and providing feedback for an "active" STEM class with her expectations for a "regular math class". Should regular or on-level education classes be expected to have active learning consistent with STEM process and practice? Should there be a difference in approach? Or are those strategies reserved for specific populations of students only? Principal D alludes to the notion that expectations

for observing STEM activities should be different for different groups of students, especially as is it relates to technology integration. Again, STEM content, process, and practices for all students is emphasized throughout the literature (NGSS Lead States, 2013). Most principals would probably agree that STEM process and practices are important for their teachers active in the interdisciplinary domain. But, there appears to be real observational challenges inherent in the feedback from principals and administrators.

The Innovating Teaching and Learning Leadership (ITaLL) Model

Some principal preparation programs do not align with principals' real jobs (Wallace Foundation, 2016). In schools, principals and teachers collaborate in various capacities, yet in preparation programs principals and teachers are trained separately. Rarely do pre-service principals and pre-service teachers interact with one another in any meaningful way. In the Innovating Teaching and Learning Leadership (ITaLL) Model, we focus on providing experiences that align with principals' real jobs while developing principals' understanding of the STEM process and proactively influencing their views of STEM classrooms (Sterrett, Rhodes, Kubasko, Reid-Griffin, Hooker, Robinson, & Ryder, 2018). In the following paragraphs we, informed by their previous research, describe the ITaLL Model for pre-service principals that includes a collaborative activity with prospective teachers around supervision. Within the ITaLL Model pre-service principals (PSP) and pre-service teachers (PST) in secondary level STEM fields share conversations, experiences, and feedback impacting teaching and learning (see Figure 1).
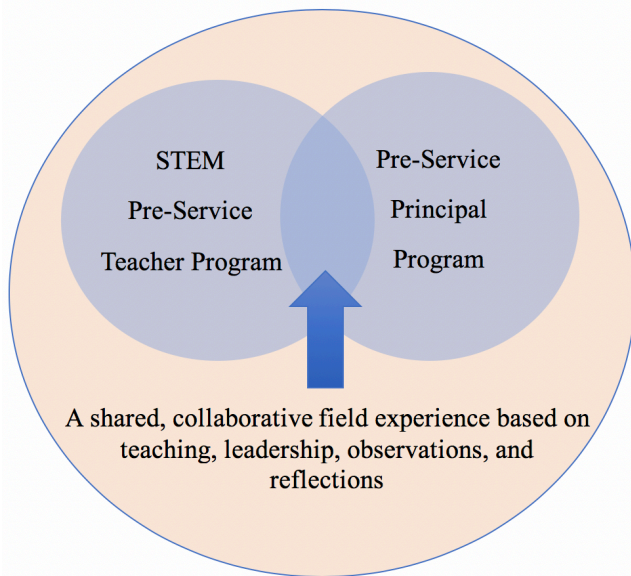
Figure 1:
The Innovating Teaching and Learning Leadership (ITaLL) Model

Teacher preparation	Principal preparation
Coursework about teaching	Coursework about leadership
Shared, collaborative field-based experiences, with teaching and leadership components	
Clinical Internship with more experience with collaborative observations	
Completion/ Certification	Completion/ Certification
Teach in classroom; proactively learn from others	*Lead in school; affirm and share highlights from within*
Have a discussion together about teaching and learning	
Reflect on teaching and leading **together**. . . and change.	

Both PSPs and PSTs complete coursework and field experiences within their university-sponsored programs. When creating the ITaLL Model we identified goals and activities within the courses and field experiences where PSPs and PSTs could benefit and learn from collaborating around supervision (see Figure 2). The goal for PSPs within the ITaLL Model is to provide a context to notice the STEM process and practices during teacher observations with the intent to provide meaningful feedback to PSTs. The goal for PSTs is to receive the feedback and learn how to reflect on their teaching in a nonevaluative way. The effort is designed to create a PSP- and PST-collaborative partnership, to improve the supervision experience and provide a vehicle for meaningful feedback. The participants include PSTs in their final year of a teacher preparation program. They take an instructional methods course related to their content area and complete field experiences in local high schools. The PSPs take a two-

semester internship course, which is facilitated and organized in an online class format.

Figure 2:
The Innovating Teaching and Learning Leadership (ITaLL) Multilayer Applied Learning Project

STEM
Pre-Service
Teacher Program

Pre-Service
Principal
Program

A shared, collaborative field experience based on teaching, leadership, observations, and reflections

In the ITaLL Model the PSPs and PSTs progress through three cycles of planning, sharing, and reflecting (Glickman, Gordon, & Ross-Gordon, 2001; Goldhammer, 1969). The planning stage allows the PSPs and PSTs to prepare for an authentic classroom observation. The sharing stage is when the virtual classroom observation takes place. After the observation, the PSPs and PSTs go through the reflection stage to share their thoughts about the observation and to process the learning experience. While the overall structure is consistent over three observation cycles, there are some subtle differences between the first two cycles and the final cycle. In the following paragraphs we provide specific details about the differences.

Observation Exercise – Sample Teaching Video Analysis

Over the first two observation and reflection cycles, the PSTs and PSPs utilize externally sourced teaching videos of authentic STEM-infused classrooms. The Accomplished Teaching, Learning and Schools (ATLAS, National Board for Professional Teaching Standards, 2018) database, a product of the National

Board for Professional Teaching Standards certification process, is employed by the ITaLL instructors to serve the PSTs as videos to analyze practice. The PSTs and PSPs watch the short videos that are approximately 15 minutes in length. While the videos stand alone, they do include contextual features such as teacher commentary and instructional materials that serve as supporting documentation for the participants. During these first two cycles the participants, guided by their class instructors, work within their respective groups and courses to complete each cycle.

During the planning stage the PSPs learn about STEM process and practices and classroom walkthroughs. In partnership with their course instructors, the PSPs outline their learning goals for their observations, discuss how to focus their attention on student thinking during the observation, and reflect on how to provide meaningful feedback to teachers. The PSPs review the observation protocols that will be employed during the observation. While PSTs also set learning goals with their course instructors and learn about STEM process and practice, they have a slightly different focus during the planning stage. The analysis they do is to prepare them to notice and interpret student thinking. Given the struggles PSTs have related to noticing student thinking when they observe videos (Jacobs et al., 2010), they initially view the selected ATLAS video prior to coming to class and complete a pre-analysis questionnaire with carefully designed prompts. Upon arrival to class, the participants are organized into small groups to share their recorded observations with their peers. This part of the experience is especially important for PSTs because it gives them a chance to notice and discuss whatever they highlighted as being important when they observed the video.

Next, during the sharing stage, PSTs watch a small segment of the same ATLAS video a second time, together. The purpose is to explicitly highlight a segment of the video where a key instructional moment is taking place. PSPs watch the same video in their respective course and use their observation protocols to collect data and evidence for the goals they designed during their planning stage. During the observation all participants focus their attention on their intended learning goals. They record their observations, document relevant evidence from the videos, and again

share their results with their peers. PSPs and PSTs will use similar observation protocols to focus their attention and take notes.

Lastly, during the reflecting stage the participants discuss their observations pertaining to the learning goals. The analysis prompts for the PSPs and PSTs are different. The PSPs use data from their observation protocols and are encouraged to focus on the STEM process. Then the PSPs consider what feedback they might provide the teachers and prioritize the feedback to consider what may be more relevant to share with teachers. The PSTs are encouraged to focus their discussions on student thinking and how the thinking might be connected to classroom instruction. Furthermore, the PSTs are provided a sample of principal feedback and asked to reflect on the idea and consider how they could use the feedback to improve their teaching practice. Throughout this stage all participants are asked to provide evidence or data to support any claims they make about their classroom observations.

Observation Exercise – Teaching Observation

After completing the first two observation and reflection cycles with ATLAS videos, the PSTs and PSPs apply what they have learned and complete a unique third cycle together. The PSTs are asked to record themselves for at least 20 minutes in their field experience in the schools. The videos used during this cycle are from the PSTs' classrooms instead of the externally sourced teaching videos. The recorded video is uploaded to a password protected server and shared with their partnering PSP's. The final teaching observation and reflection cycle provides an authentic experience for both the PSPs and the PSTs.

Again, the planning stage of the cycle allow participants to plan for the observation. For this final cycle the PSTs develop their lesson plans for the high school class they are teaching. They create learning goals for their lessons and consider how their instruction supports students meeting those goals. The PSTs prepare a written context for teaching narrative which will provide more information to PSPs during the next stage. The PSPs will develop, in partnership with the PSTs, the goals for their observations. The PSPs' goals will focus their observation and consequently influence the feedback and reflection. PSPs review their

observation protocols to make sure there is alignment between the protocol and their goals.

Next, during the sharing stage, the PSTs teach a class in their field experience and video record their instruction. The PSTs select a 10-minute portion of their video to share with PSPs. The PSTs review and edit their context for teaching narrative and upload their videos and narratives to a password-protected server (i.e., Taskstream). Once the videos and narratives are uploaded, the PSPs observe the videos and read the PSTs' narratives. The PSPs use their walk-through observation protocols to focus their attention on important features of the STEM process in the lesson.

In the last stage of the teaching observation cycle—reflection—PSTs first review and reflect on their videos prior to receiving feedback from the PSPs. The prompts are similar to the sample teaching analysis video prompts, which focus the PSTs attention on student thinking. The PSPs organize their data from the observation protocols and decide what feedback they plan to share with the PSTs. Once the PSPs provide the feedback, there is time set aside for the PSTs and PSPs to have a conversation about the feedback. The conversation about the feedback is essential because it gives the participants time to jointly reflect on the experience and learn about their practice from each other.

Discussion

There is a conflict within the supervision role of principals (Sullivan & Glanz, 2013). On one hand they are tasked with supporting teachers in the instructional process. However, they are also required to evaluate the teacher. We have found that principals clearly want to assist STEM-infused teachers to grow in their professional practice and they offer constructive feedback that applies to general pedagogical skills and strategies that can apply across all disciplines. They maintain high expectations for STEM-infused classrooms and hope to see engaging, hands-on learning that addresses higher order thinking skills. But when asked, the principals quickly identify the multitude of obstacles that they face when actually providing STEM-specific feedback to teachers including a lack of content knowledge in the discipline and a shallow depth of understanding of STEM process and practice. Even among the two principals with backgrounds in STEM

content, their understanding of reform-minded STEM process and practices was limited, leading to teacher feedback that wasn't STEM specific. Teacher and principal education programs need to do more to prepare our principals to be successful in the development and support of a STEM-literate teaching force.

Based on research and a need for change, faculty in both the teacher education and principal education programs have come together to design a solution. Working across departments in the college of education, the ITaLL Model has been developed and integrated, bringing together both the pre-service teacher education and the pre-service principal education student populations. Three iterative observation and reflection cycles have been designed to link both sets of students to effective professional practice that benefits STEM supervision. The key components of each cycle include professional planning, peer sharing and active discourse and reflection. This collaborative partnership aims to improve the experience for principal supervisors in training and provide a vehicle for meaningful feedback for pre-service teachers to be used in their emerging practice.

There are limitations and challenges within the engaged work that shouldn't be overlooked. When integrating two distinctly disparate academic programs, there are the challenges of time and resources. The faculty involved on the team represented academic deans, mathematics and science educators, principal educators and assessment specialists. In courses where student collaboration is taking place and are integral to the success of each academic program, the inclusion of another student learning activity presents challenges to faculty and students. Compromises had to be made across programs. Interdisciplinary education in any context is a challenge on many university campuses as programmatic goals, objectives and outcomes must be merged. Certification concerns are always an issue as both programs require state mandates be met. There is unfortunately little time in the course curriculum to define, develop and train principals in STEM content, process, and practice. So, the developers had to be efficient in their expertise and create a learning environment that maximizes the pre-existing skills of the pre-service principal population. As a final note, we believe that we need to demonstrate for our prospective

educators how to overcome these challenges to collaborate and create interdisciplinary learning opportunities for students. It is important for university faculty to show ways to collaborate across disciplines as we hope our STEM teachers and principals do the same at the K-12 school level.

Acknowledgments

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